VERIFICATION OF TRANSLATION

I, the below named translator, hereby declare that:

My name and post office address are as stated below:

That I am knowledgeable in the English language and in the Japanese language in which the below identified Japanese application was filed, and that I believe the attached English translation of the Japanese application No. 2000-239396 is a true and complete translation of the above identified Japanese application as filed.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated: August 1, 2003

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[Document Name] SPECIFICATION

[Title of the Invention] LEAD FRAME, SEMICONDUCTOR DEVICE PRODUCED BY USING THE SAME AND METHOD OF PRODUCING THE SEMICONDCUTOR DEVICE

[Claims]

[Claim 1]

A lead frame comprising a tie bar to which an element loading portion to be loaded with a semiconductor element is connected by a lead forming portion, said time bar being connected to an outside frame formed with positioning holes, characterized in that

a deformable portion is included in said tie bar for preventing said outside frame from deforming.

[Claim 2]

The lead frame as claimed in claim 1, characterized in that said deformable portion is configured to deform during lead forming, which bends said lead forming portion, to thereby absorb stress acting on said tie bar.

[Claim 3]

The lead frame as claimed in claim 2, characterized in that said deformable portion is configured to absorb a force pulling said tie bar toward said element loading portion.

[Claim 4]

The lead frame as claimed in any one of claims 1- 3, characterized in that the semiconductor device comprises a photocoupler.

[Claim 5]

A frame for forming a semiconductor device, characterized in that the lead frames as claimed in any of claims 1-4 are combined such that element loading portions to be loaded with semiconductor elements thereof are positioned one above the other.

[Claim 6]

The frame for forming a semiconductor device as claimed in claim 5, characterized in that the element loading portions of only one of the lead frames are bent relative to lead forming portions associated therewith.

[Claim 7]

The frame for forming a semiconductor device as claimed in claim 5 or 6, characterized in that the lead forming portions are bent while being crushed to be locally thinned and extended.

[Claim 8]

The frame for forming a semiconductor device as claimed in claim 6, characterized in that said deformable portion is sealed with resin to thereby form a reinforcing portion that prevents said deformable portion from deforming after lead forming.

[Claim 9]

The frame for forming a semiconductor device as claimed in claim 7, characterized in that said reinforcing portion includes said deformable portion and a portion of said outside frame to which said deformable portion is connected.

[Claim 10]

The frame for forming a semiconductor device as claimed in any

one of claims 5-9, characterized in that said deformable portion prevents the positioning holes and the element loading portions from being displaced to thereby maintain a preselected positional relation between said positioning holes and said element loading portions.

[Claim 11]

A semiconductor device comprising a pair of element loading portions loaded with semiconductor elements and positioned one above the other and seal resin sealing said pair of element loading portions, leads connected to a respective semiconductor element being exposed on said seal resin, characterized in that

only one of said pair of element loading portions is bent upward relative to said leads.

[Claim 12]

The semiconductor device as claimed in claim 11, characterized in that the leads are positioned on an extension of a bottom of said seal resin.

[Claim 13]

The semiconductor device as claimed in claim 11 or 12, characterized in that said semiconductor device comprises a photocoupler comprising a light emitting element and a light-sensitive element that face each other.

[Claim 14]

The semiconductor device as claimed in any one of claims 11-13, characterized in that the leads are implemented by lead forming portions included in the frame as claimed in any one of claims 5-

10.

[Claim 15]

A method of producing a semiconductor device by using the frame as claimed in any one of claims 5-10, characterized by comprising the:

a lead forming step of bending lead forming portions after primary sealing using light-transmitting resin; and

a sealing step of sealing deformable portions included in a lead frame after said lead forming step.

[Claim 16]

The method of producing a semiconductor device as claimed in claim 15, characterized in that said sealing step is executed at the same time as secondary sealing using light-intercepting resin and executed after said lead forming step.

[Claim 17]

The method of producing a semiconductor device as claimed in claim 15 or 16, characterized in that said lead forming step comprises bending the lead forming portions while crushing said lead forming portions to thereby locally thin and extend said lead forming portions.

[Claim 18]

The method of producing a semiconductor device as claimed in any one of claims 15-17, characterized in that said lead forming step forms a step corresponding to a thickness of a bottom of the resin used for the secondary sealing.

[Detailed Description of the Invention]

[0001]

[Field of the Art to Which the Invention Belongs]

The present invention relates to a lead frame, a semiconductor device produced by using the same and a method of producing the semiconductor device and more particularly to a lead frame loaded with photocoupling elements, a semiconductor device produced by using the lead frame, and a method of producing the semiconductor device.

[0002]

[Prior Art]

A double sealed photocoupler belongs to a family of semiconductor devices. The double sealed photocoupler is produced by a procedure including primary sealing using light-transmitting resin and secondary sealing using light-intercepting resin.

[0003]

FIG. 12 is a section demonstrating a procedure for producing a conventional double sealed photocoupler. (While the photocoupler is produced on a lead frame, the lead frame is not shown.)

[0004]

As shown, a lead frame 1a is depressed and loaded with a light emitting element 1 while a lead frame 2a is also depressed and loaded with a light-sensitive element 2. The lead frames 1a and 2a are paired in the position (see (a)). The lead frames 1a and 2a are then positioned one above the other such that the light emitting element 1 and light-sensitive element 2 face each other (see FIG. (b)).

[0005]

Subsequently, light transmitting, primary seal resin 3a seals the light emitting element 1 and light-sensitive element 2 to thereby secure an optical path. More specifically, the primary seal resin 3a is configured as a rhombic cube. The lead frames 1a and 2a each protrude from a particular apex of the rhombic cube (see (c)).

[0006]

Light intercepting, secondary seal resin 3b seals the primary seal resin 3a (see (d)). Finally, the lead frames 1a and 2a are formed for mounting, thereby completing a photocoupler 4 (e)).

[0007]

There is also known a double sealed photocoupler in which a lead frame for forming lead forming portions is accommodated in a secondary molding to thereby reduce the size of the photocoupler (see Japanese Patent Laid-Open Publication No. 9-83013).

[0008]

FIG. 13 shows another conventional photocoupler. As shown, the photocoupler, labeled 5, includes a primary molding 3a sealed by light transmitting, primary seal resin. Subsequently, the lead frames 1a and 2a loaded with the light emitting element 1 and light-sensitive element 2, respectively, are formed. Thereafter, secondary seal resin seals the primary molding 3a and lead frames 1a and 2a in the form of a secondary molding 3b.

[0009]

Lead forming is effected with the photocoupler 4 after secondary sealing or effected with the photocoupler 5 after primary

sealing, as stated above. A specific lead forming process executed after primary sealing will be described hereinafter.

[0010]

FIG. 14 demonstrates a conventional lead forming process applicable to a photocoupler. As shown, a plurality of photocouplers 6 each have two lead (terminal) forming portions 7a protruding from each of opposite ends. Each photocoupler 6 is connected to a lead frame 7 via the respective lead forming portions 7a.

[0011]

Each lead forming portion 7a is connected to a first and a second tie bar 7b and 7c and an inner tie bar 7d. The tie bars 7b through 7d extend between two parallel, outside frames 7e (see (a)).

[0012]

More specifically, three tie bars 7b through 7d are arranged in parallel at each of opposite sides of the array of photocouplers 6 and extend substantially perpendicularly to the lead forming portions 7a. The outside frames 7e each are formed with holes 8 for positioning the lead frame 7 (see (a)).

[0013]

The lead forming process begins after the primary sealing (see (a)). First, the inner tie bars 7d are cut off while the first and second tie bars 7b and 7c are left (see (b)). Subsequently, the lead forming portions 7a are bent between the individual photocoupler 6 and the first tie bars 7b (lead forming) (see (c)).

[0014]

Particularly, lead forming must be effected after the primary sealing in order to raise the primary molding 3a, which accommodates the light emitting element 1 and light-sensitive element 2 (see FIG. 13).

[0015]

[Problems to Be Solved by the Invention]

The lead forming process described above has the following problems. When the lead forming portions 7a of the photocouplers 6 are bent on the lead frame 7, portions of the lead frame 7 where the tie bars 7b and 7c and outside frames 7e are connected irregularly deform (see FIG. 14, (c)). This is because the lead forming portions 7a bent by lead forming pull the tie bars 7b and 7c inward.

[0016]

As a result, the positioning holes 8 formed in the frames 7e are displaced and prevent the lead frame 7 from being accurately positioned at a stage following the lead forming stage. Moreover, stress ascribable to lead forming remains in the individual photocoupler 6 and brings about package crack or similar trouble later.

[0017]

Particularly, it is necessary to bend the leads before secondary sealing (see FIG. 13). Stress ascribable to the bending of the leads causes even the lead frame 7 loaded with photocouplers to deform by 0.2 mm or so. Such deformation disturbs the positional relation between the photocouplers and the positioning holes 8. This

also obstructs accurate positioning after secondary sealing and therefor the production of photocouplers.

[0018]

More specifically, lead forming is effected after the positioning holes 8 have been formed in the lead frame 7. Therefore, when the leads are bent, stress act on the holes 8 and cause them to deform. As a result, the holes 8 are displaced. The holes 8 are used to position the lead frame 7 before and after lead forming, and each has a relative positional relation with the individual photocoupler 6. The holes 8 are positioned at substantially the same interval.

[0019]

It is therefore important to maintain the accurate positional relation or distance between the holes 8 and the individual photocoupler 6. All stages on a production line rely on positioning based on the holes 8.

[0020]

It is an object of the present invention to provide a lead frame free from deformation during lead forming while reducing the size of a semiconductor device to be loaded thereon, a semiconductor device produced by using the lead frame, and a method of producing the semiconductor device.

[0021]

[Means for Solving Problems]

In order to achieve the above object, in a lead frame including a tie bar to which an element loading portion to be loaded with a

semiconductor element is connected by a lead forming portion, the time bar being connected to an outside frame formed with positioning holes, the present invention is characterized in that a deformable portion is included in the tie bar for preventing the outside frame from deforming.

[0022]

In the above configuration, the element loading portions to be loaded with semiconductor elements are connected to the outside frames by the tie bars each having deformable portions that protect outside frames from deformation. The outside frames are formed with positioning holes. The lead frame is therefore free from deformation during lead forming while promoting the miniaturization of the semiconductor devices.

[0023]

Further, a semiconductor device can be produced by using a method of producing the semiconductor device using the lead frame of the present invention.

[0024]

[Embodiment of the Invention]

An embodiment of the present invention will be described hereinafter.

[0025]

FIG. 1 is an isometric view showing an embodiment of the lead frame in accordance with the present invention. There are shown a lead frame 10a assigned to the light emission side (see (a)) and a

lead frame 10b assigned to the light receiving side (see (b)). There are also shown a frame for forming photocouplers, which are a specific form of semiconductor devices, (see (c)). The lead frames 10a and 10b are respectively loaded with light emitting elements and light-sensitive elements, which will be described specifically later.

[0026]

The light emitting elements and light-sensitive elements may be implemented as LEDs (Light Emitting Elements) and phototransistors, respectively. The lead frame 10a is reversed in orientation and superposed on the lead frame 10b, so that the light emitting elements and light-sensitive elements face each other.

[0027]

The lead frame 10a includes a pair of parallel, outside frames 11a and 11b, a first and a second tie bar 12a and 12b, an inner tie bar 12c for reinforcement, and a plurality of (four in the illustrative embodiment) element loading portions 13a.

[0028]

The tie bars 12a through 12c extend between the opposite frames 11a and 11b. Each element loading portion 13a is connected to the inner tie bar 12c and second tie bar 12b by two depressed, lead (terminal) forming portions 14. A light-sensitive element (not shown) is loaded on the rear surface of each element loading portion 13a face down and connected to preselected positions by metal wires.

[0029]

As shown in FIG. 1(b), the lead frame 10b includes element loading portions 13b connected to an inner tie bar 12c and a second tie bar 12b by two lead forming portions 14. A light emitting element 17 is loaded on each element loading portion 13b and connected to preselected positions by metal wires although not shown specifically. The light emitting element 17 is coated with protection resin.

[0030]

The first and second tie bars 12a and 12b have substantially the same width that is greater than the width of the rod-like inner tie bar 12c. The second tie bars 12b each are connected to the frames 11a and 11b by deformable portions 15 at opposite ends thereof.

[0031]

The deformable portions 15 are implemented as rods having substantially the same diameter as the inner tie bars 12c, and each easily deforms at least in the direction parallel to the frames 11a and 11b. For example, each deformable portion 15 has a length one time or more greater than a width or has a width of about 0.3 mm, in which case the lead frame will be about 0.2 mm thick or less.

[0032]

Holes 16 for positioning the lead frame 10a is formed in one outside frame 11a. The frames 11a and 11b are positioned at opposite sides of the array of element loading portions 13a. The first and second tie bars 12a and 12b and inner tie bar 12c are arranged in parallel at each of opposite sides of the element loading portions 13a and extend substantially perpendicularly to the lead forming

portions 14. The lead forming portions 14 each are connected to the associated inner tie bar 12c.

[0033]

The lead frame 10b is opposite in position to the lead frame 10a by 180 degrees in the direction of rotation. The element loading portions 13b of the lead frame 10b facing the element loading portions 13a are not depressed. The holes 16 of the lead frame 10b align with the holes 16 of the lead frame 10a. The lead frame 10b is therefore identical in configuration with the lead frame 10a in that it includes a pair of frames outside 11a and 11b, first and second tie bars 12a and 12b, and inner tie bar 12c.

[0034]

Light emitting elements 17 each are loaded on the front surface of a particular element loading portion 13b face up while facing, but not contacting, one of the light-sensitive elements loaded on the element loading portions 13a (see (b)).

[0035]

The frame 10c for producing semiconductor devices is prepared by laying the lead frame 10a over the lead frame 10b and welding or otherwise connecting them together (see (c)). At this instant, the element loading portions 13a overlie the element loading portions 13b. The holes 16 of the lead frames 10a and 10b are exposed to the outside. The frames 11a and 11b are joined together.

[0036]

In this manner, in the frame 10c, only one of the lead frames

(lead frame 10a) has the element loading portions 13a stepped relative to the associated lead forming portions 14.

[0037]

With the frame 10c, it is possible to produce an optical MOS (Metal Oxide Semiconductor) or similar photocoupler that optically couple a light emitting side and a light-sensitive side. Hereinafter will be described a procedure for producing such a photocoupler.

[0038]

FIG. 2 is a section showing a method of producing a semiconductor device by using the lead frame of FIG. 1. FIG. 3 is an isometric view showing the method of producing a semiconductor device by using the lead frame of FIG. 1 (part 1). FIG. 4 is an isometric view showing the method of producing a semiconductor device by using the lead frame of FIG. 1 (part 2).

[0039]

First, as shown in FIGS. 3 through 4, the lead frame 10a having the element loading portions 13a loaded with the light-sensitive elements 18 and the lead frame 10b having the element loading portions 13b loaded with the light emitting elements 17 are prepared (see FIG. 2(a)).

[0040]

Subsequently, the lead frames 10a and 10b are combined such that the light emitting elements 18 and light-sensitive elements face each other, but do not contact each other, thereby constituting the frame 10c (see FIG. 2(b)).

[0041]

Each light-sensitive element 18 is bonded to the respective element loading portion 13a by wires 19. Each light emitting element 17 is precoated with, e.g., transparent silicone resin and then bonded to the respective element loading portion 13b by wires 19.

[0042]

Subsequently, each light emitting element 17 and associated light-sensitive element 18 of the frame 10c are sealed by light transmitting, primary seal resin 20 in order to secure an optical path. The seal resin 20 is configured as a trapezoidal cube. The lead forming portions 14 protrude from the portions of opposite slants of the trapezoidal cube close to the bottom (see FIGS. 2(c) and 3(a)).

[0043]

After the primary sealing, the inner tie bars 12c are cut off while the first and second tie bars 12a and 12b are left. As a result, the seal resin 20 is connected to each second tie bar 12b by two lead forming portions 14 while each tie bar 12b is connected to the frame 11a or 11b via the deformable portions 15.

[0044]

Stated another way, the seal resin 20 is connected to the frames 11a and 11b only by the deformable portions 15, which are easily deformable in the direction parallel to the frames 11a and 11b like, e.g., hanging pins (see FIG. 3(b)).

[0045]

The lead forming portions 14 are bent between the primary seal

resin 20 and the second tie bars 12b (inner lead forming) in order to raise the seal resin 20 (see FIGS. 2(d) and 4(c)). More specifically, the lead forming portions 14 are bent while being crushed and thereby locally thinned and extended.

[0046]

An optical coupling device to be produced by using the frame 10c has two lead forming portions 14 accommodated in secondary seal resin 21 (see FIGS. 2(e) and 4(d)), as will be described hereinafter. It is therefore necessary to execute lead forming after the primary sealing in order to raise the primary seal resin 20. The lead forming forms a step substantially corresponding to the thickness of the bottom of the secondary seal resin 21.

[0047]

The lead forming step that bends the lead forming portions 14 while crushing them will be described specifically with reference to FIG. 6. Assume the step in which after the cutting of the inner tie bars 12c following the primary sealing, each primary seal resin 20 and frames 11a and 11b are supported only by the deformable portions 15. In this condition, an upper and a lower mold 22 sandwich each lead forming portion (inner lead) 14 so as to press it downward while crushing it.

[0048]

Consequently, part of the lead forming portion 14 crushed and bent is extended to a thickness that is substantially three-fifths of the original thickness of the lead forming portion 14. The thin,

extended part absorbs the distance over which the lead forming portion 14 is pulled during deformation, thereby reducing deformation. This successfully prevents lead forming from influencing the frame 10c. Experiments showed that for a designed amount of deformation of about 0.223 mm, the actual amount of deformation was about 0.07 mm, i.e., about one-third of the designed amount.

[0049]

The deformation of each lead forming portion 14 pulls the second tie bar 12b inward (toward the primary seal resin 20) during the above lead forming. However, the deformable portion 15 deforms and surely, sufficiently absorbs the force, which pulls the tie bar 12b, in combination with the crushing and bending operation (see FIG. 4(c)).

[0050]

More specifically, the deformable portion 15 is configured to absorb stress acting on the tie bar 12b, which is crushed and bent, by deforming itself in the direction parallel to the frames 11a and 11b.

[0051]

The tie bar 12b and frames 11a and 11b are therefore free from deformation described with reference to 3C and prevent the holes 16 of the frames 11a and 11b from being displaced due to irregular deformation.

[0052]

After the lead forming described above, the light intercepting,

secondary seal resin 21 seals the primary seal resin 20 in order to shield extraneous light (see FIGS. 2(e) and 4(d)).

[0053]

At the same time, the secondary seal resin 21 seals the deformable portions 15 (four in FIG. 4(d)) to thereby form reinforcing portions 23 for reinforcing the portions 15. The reinforcing portions 23 constitute dummy packages not containing any product.

[0054]

FIG. 6 is a plan view showing how the reinforcing portions 23 are formed more specifically. As shown, each reinforcing portion 23 extends over the associated first and second tie bars 12a and 12b while sandwiching them from opposite sides. The reinforcing portion 23 covers not only the deformable portion 15 connecting the frame 11a or 11b and second tie bar 12b, but also the portion of the first tie bar 12a connected to the frame 11a or 11b.

[0055]

Subsequently, deburring is executed with the double sealed product portions or package portion by using, e.g., a water jet. After deburring, the leads are plated, and then the lead forming portions 14 of the individual package are cut to a necessary length. Finally, as shown in FIG. 7C, the package is removed from the frame 10c to thereby complete a photocoupler 25 for planar mounting.

[0056]

The leads 24 of the photocoupler 25 are positioned at the bottom of the package sealed by the secondary seal resin 21 or the

extension thereof.

[0057]

During deburring, a downward force acts on the product portions sealed by the secondary seal resin 21. However, the deformable portions connected to the second tie bars 12b and frames 11a and 11b are reinforced by the reinforcing portions 23 and therefore prevent the product portions from being deformed downward.

[0058]

FIG. 7 is an isometric view for describing the influence of deburring. As shown, when a downward pressure acts on the individual product portion sealed by the secondary seal resin 21, the product portion deforms downward together with the second tie bars 12b because it is supported by the frames 11a and 11b via the deformable portions 15.

[0059]

More specifically, the product portions are connected to the frames 11a and 11b by the deformable portions 15 and therefore easily displaced. This is particularly true when the product portions are cleaned by a water jet before plating.

[0060]

However, the reinforcing portions 23 reinforcing the deformable portions 15 prevent the portions 15 from deforming, i.e., prevent the product portions from deforming via the second tie bars 12b that include the portions 15.

[0061]

FIG. 8 shows specific configurations of each deformable portion 15. In the illustrative embodiment, the deformable portion 15 is implemented as a handing pin, as stated earlier. As shown in FIG. 8, the deformable portion 15 may be replaced with a deformable portion 15a larger in diameter at opposite end portions than at the intermediate portion or a deformable portion 15b bent in the form of narrow steps. Further, use may be made of a deformable portion 15c consisting of a plurality of (e.g. two) pieces. The crux is that the deformable portion be easily deformable in the direction parallel to the frames 11a and 11b, absorbing a force that pulls the second tie bars 12b inward toward the element loading portions.

[0062]

The frame 10c is made up of the depressed lead frame 10a and non-depressed lead frame 10b.

[0063]

FIG. 9 shows the structure of the frame 10c in which the lead frame 10a is depressed while the lead frame 10b is not depressed. As shown in FIG. 12A, one of the frames or lead forming portions 14 is depressed while the other is left flat. By contrast, as shown in FIG. 12B, a conventional structure has both frames 1a and 1b, which are respectively assigned to the light emission side and light receiving side, depressed by substantially the same amount (see (b)).

[0064]

Only one of the frames 10a and 10b is depressed deeply enough to allow the other frame to remain flat. The product portion is

raised, or shifted, by an amount *a* in order to guarantee the thickness of the secondary seal resin. The amount of shift *a* is smaller than the amount of shift *b* required of the conventional product portion shown in FIG. 12B. This not only reduces the deformation of the frames 10c ascribable to lead forming, but also promotes easy processing of the frame 10c.

[0065]

FIG. 13 is a section showing the structure of the present invention in which one side of the frame is depressed. As shown, in the photocoupler having the structure described above, only the light emitting element generate heat during operation. It is therefore important to release the heat for enhancing the reliability of the semiconductor device. Generally, most of the heat generated by the light emitting element is propagated through the lead frame (13b), as indicated by hatching in FIG. 13. Therefore, if the distance between the light emitting element and the mounting surface *c* of a circuit board is reduced, then the heat can be efficiently released to the circuit board.

[0066]

More specifically, in the photocoupler 25 of the illustrative embodiment (see FIG. 4F(e)), the leads or lead forming portions 14 are accommodated in the secondary seal resin 21 while the terminals are exposed at the bottom of the seal resin 21. In this configuration, a distance *d* between the light emitting element and the mounting surface *c* (heat path *d* hereinafter) is shorter than the conventional

distance. Further, the heat path of the photocoupler 25 is shorter than the heat path of another conventional configuration (see FIG. 13).

[0067]

The illustrative embodiment therefore reduces thermal resistance, i.e., the temperature elevation of a chip itself relative to power consumption and thereby enhances the reliability of a product, compared to the conventional configuration.

[0068]

As stated above, the lead frame of the illustrative embodiment includes the plastically deformable portions 15. A photocoupler using such a lead frame is produced by a procedure including a lead forming step or crushing and bending step and a step of forming the reinforcing portions 23 around the deformable portions 15.

[0069]

More specifically, in the inner lead forming step following the primary sealing step, portions formed of an easy-to-deform material and provided with an easy-to-deform configuration are formed between the lead frame and the product portions beforehand, so that the positional relation between the former and the latter does not vary. The above portions deform to prevent deformation from being transferred to the frame.

[0070]

Further, the reinforcing portions 23 protect the product portions from deformation in subsequent stages (particularly the

deburring stage) ascribable to the deformable portions 15 that would otherwise reduce the strength of the product portions.

[0071]

This successfully reduces a mounting area to be allocated to, e.g., a double sealed photocoupler. In addition, deformation ascribable to lead forming is not transferred to the lead frame, so that the positioning holes 16 and product portions are maintained in the preselected positional relation.

[0072]

The reduction of deformation from about 0.223 to about 0.07 mm, i.e., by about one-third is particularly significant. Considering the state-of-the-art lead frame as thin as about 0.2 mm, a displacement of about 0.2 mm would result in the loss of the secondary seal resin for intercepting light.

[0073]

Moreover, the deformable portions 15 compensate for some bend of the portions where the product forming portions and lead frame join each other. In addition, the lead frame is scarcely pulled during lead forming because only one of the element loading portions is bent upward above the associated leads. This is also successful to maintain the preselected positional relation between the product forming portions and the lead frame; otherwise the holes 16 would be displaced and make the following steps impracticable.

[0074]

In the illustrative embodiment, the frame 10c has the lead

frames 10a and 10b combined together with the former overlying the latter. Alternatively, the lead frames 10a and 10b may be shifted in the horizontal direction and constructed integrally with each other with the frames 11a and 11b thereof not overlapping each other.

[0075]

FIG. 11 shows a specific W type photocoupler to which the present invention is similarly applicable. As shown, the W type photocoupler, labeled 26, includes liquid seal resin 27 in place of the primary molding in order to form an optical path.

[0076]

[Effects of the Invention]

In summary, in accordance with the present invention, a lead frame includes a plurality of tie bars including tie bars each having deformable portions that protect outside frames from deformation. The outside frames are formed with positioning holes. Element loading portions to be loaded with semiconductor elements are connected to the outside frames by such tie bars. The lead frame is therefore free from deformation during lead forming while promoting the miniaturization of the semiconductor devices.

[0077]

Further, a semiconductor device can be produced by using a method of producing the semiconductor device using the lead frame of the present invention.

[0078]

[Brief Description of the Drawings]

[FIG. 1]

is an isometric view showing a lead frame embodying the present invention.

[FIG. 2]

is a section demonstrating a procedure for producing a semiconductor device by using the lead frame of the illustrative embodiment.

[FIG. 3]

is an isometric view demonstrating the procedure for producing a semiconductor device by using the lead frame of the illustrative embodiment (part 1).

[FIG. 4]

is an isometric view demonstrating the procedure for producing a semiconductor device by using the lead frame of the illustrative embodiment (part 2).

[FIG. 5]

is a section for describing lead forming unique to the illustrative embodiment.

[FIG. 6]

is a plan view showing reinforcing portions also unique to the illustrative embodiment.

[FIG. 7]

is an isometric view for describing the influence of deburring.

[FIG. 8]

is a view showing another specific configurations of a deformable portion included in the illustrative embodiment.

[FIG. 9]

is a section for describing a configuration unique to the illustrative embodiment in which only one of two lead frames is depressed (part 1).

[FIG. 10]

is a section for describing a configuration unique to the illustrative embodiment in which only one of two lead frames is depressed (part 2).

[FIG. 11]

is a section showing a W type photocoupler to which the present invention is similarly applicable.

[FIG. 12]

is a section demonstrating a conventional procedure for producing a double sealed photocoupler.

[FIG. 13]

is a section showing the configuration of another conventional photocoupler.

[FIG. 14]

is an isometric view for describing lead forming included in the conventional procedure for producing a photocoupler.

[List of Reference Numerals]

10a, 10b lead frame

10c frame

11a, 11b outside frame

12a first tie bar

12b second tie bar

12c inner time bar

13a, 13b element mounting portion

14 lead forming portion

15 deformable portion

16 hole

17 light-sensitive element

18 light emitting element

20 primary seal resin

21 secondary seal resin

22 mold

23 resin reinforcing portion

24 lead

25, 26 photocoupler

[Document Name] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Problem] To provide a lead frame free from deformation during lead forming while reducing the size of a semiconductor device to be loaded thereon, a semiconductor device produced by using the lead frame, and a method of producing the semiconductor device.

[Solving Means]

In a lead frame in which a device mounting portion 13 to be loaded with a semiconductor device is connected to outside frames 11 formed with positioning holes 16 by tie bars 12, the tie bars 12 each include a deformable portion that protect the outside frames 11 from deformation.